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# OBJECT-ORIENTED APPROACH WITHIN A QUADTREE BASED GIS

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## ABSTRACT

The object-oriented approach is a powerful tool for modelling the real world. It allows a description of the spatial and attribute data of a geographical object, and encapsulated methods at the same level. By incorporating the abstraction mechanisms such as generalisation and aggregation, it can be very efficient tool for application designers to model complex geographic situations. The aim of this paper is to illustrate how such approach could be modelled within a geographical information system (GIS) in which a spatial database is represented in a raster quadtree structure.

Key words: geographical information system, object oriented approach, data modelling, raster, vector, quadtree, entities, and objects.

## INTRODUCTION

A GIS requires interactive edit/query, and powerful spatial analysis capabilities for a large volume of geographical data. Existing data models (hierarchical, network, and relational) provide an incomplete structure of sophisticated information particularly in cartography. This is due to the fact that the cartographic phenomenon is composed of complex information which is densely related (Burrough , 1998).

Most of the present database management systems (DBMS) are built on the relational model, which organises data as tables or relations. The relational model is too simple for modelling the data describing the physical world and it lacks the powerful concept of recursion which is crucial for modelling the complex situations such as spatial data and their subdivisions.

In recent years, research in software engineering has promoted an object-oriented method by which real world objects and their relevant operations are modelled in a program. This approach is very useful for application areas like GIS because it naturally supports treatment of complex objects. According to David et al. (1991), a GIS will benefit

from the use of object-oriented databases in different forms, for example, the system architecture will become clearer and easier to maintain so that software systems will have a longer life cycle, and the programmers need not to worry about aspects of the physical location of data, instead, a unified set of commands provides the functionality for storage and retrieval of data.

During the last years, many attempts have been made to compress the spatial data structures and a number of methods (e.g. run-length, chain coding, and block coding) have been introduced. The purpose of this study is to describe how object-oriented data model (OODM) could be implemented in a GIS which has a spatial database represented in a raster quadtree structure (namely, in a structure in which the raster data have been compressed).

## THE EXISTING DATA MODELLING TECHNIQUE AND OBJECT-ORIENTED APPROACH

Real world is a set of various interrelated objects at different levels of details and its modelling in a computer environment is carried out in two stages:

- Design of the conceptual model, which describes a conceptual framework for the abstraction of the phenomena and their relationships as viewed by the user community of the database.

- Logical data model, which is the mapping of the conceptual model to a logical model specific to the DBMS.

A data modelling technique which uses the above approach is called an entity relationship modelling (ERM). This is a widely used method for a database development. However, this approach lacks a powerful and flexible approach in definition of a complex object.

An object oriented concept can be represented by using extended entity relation model which in comparison with the traditional ERM includes the concepts of subclass and superclass and attribute inheritance. This model has a top down approach which allows users to see a database as collection of interrelated complex objects which may be viewed at whatever level of detail necessary for their application. Moreover, in

OODM an entity of whatever complexity and structure can be represented by exactly one object. Each object has a unique identity which allows object sharing and updating. Objects may be concrete or abstract, and simple or complex. They could be classified into types according to the roles which they play in database and according to the attributes which they possess. The OODM is built on such basic concepts of abstraction as classification, generalisation, aggregation and propagation. Besides these abstractions, object oriented databases provide persistency in the form of methods to store, retrieve, and modify complex objects.

## THE PRESENT DATA STRUCTURE AND OODM IN A QUADTREE BASED GIS

Spatial data can be organised in either raster or vector format. In the vector structure geographical objects are represented by points, lines and areas, thus creating compact and complex data structure. There are two basic types of this structure, called spaghetti and topological. In the spaghetti model, entities are defined as strings of x,y coordinates and because of that it is inefficient for spatial analysis, since spatial relationships which are implicit in the original document must be obtained through computation. Therefore, this kind of structure is generally used in computer-assisted design for reproducing the original graphic images. However, in the topological model each individual line segment is recorded with the coordinates of its two end points and spatial relationships are explicitly retained. In the raster structure, points, lines and areas are stored as cells in a grid structure. It has a simple structure, because each cell is referenced by a row and column number and they all have the same size and shape. The main advantage of the raster over the vector structure is that it is easy to overlay with other layers including classified remotely sensed data to do different spatial analyses (Burrough, 1998).

Data structures of most GISs are either raster or vector based and have limited abilities to combine both. Generally, vector data could be seen as the higher resolution data, and raster data as the data with the lower resolution. A quadtree structure allows handling of both vector and raster data without loss of their advantageous characteristics. This means, after conversion to a quadtree structure, vector entities can keep their high resolution without increase of storage and for raster objects, compression will be achieved. Burrough (1998) describes the quadtree structure as

"data structure, in which objects are broken up into groups or blocks of squares that are recorded as zero if the whole block is blank". Thus if it so happens that the top left quarter of a map contained no detail at all, all that area could be set to zero in one record reducing data storage by a quarter and subdivision continues until each block is of a uniform colour or type. Spatial data structure, based on such decomposition is called regional quadtrees. The process of decomposition is represented by a tree with branching factor 4 in which the root node corresponds to the entire array, the 4 sons of the root node correspond to the quadrants, and leafs correspond to those blocks of the array for which no further subdivision is required.

To develop an object-oriented quadtree structure, a binary (double) search algorithm which is a very fast method for forming either simple or complex interrelated objects should be used using a Morton key. The Morton key sequentially assigns consecutive integers to the cells in a grid, beginning with 0, such that, the odd numbered bits denote the coordinate position along one axis in binary, and the even numbered bits denote the coordinate position along the other axis. Thus, due to Morton sequencing, all cells are implicitly represented in a two dimensional coded file and object location, represented by a Morton number is the code associated with the smallest Morton number in the file and all values related to the same objects will be included sequentially according to their orders.

## CONCLUSIONS

As seen from the paper, the existing data structuring techniques lack a sophisticated approach in data handling and management. An object-oriented data structure can be a powerful technique for database organisation and be very useful when there are large and complex datasets. It is seen that the method of object-oriented management of raster object stored in a two dimensional coded file will result in a greater storage efficiency. In future the object-oriented data structure could be beneficial in designing of a spatial related knowledge-based system.

## REFERENCES

1. Д.Амарсайхан, 2002, Газарзүйн мэдээллийн систем ба оронзайн өгөгдлийг загварчлах нь, ЭРДЭМ сонин, хх4-7.

2. Д.Амарсайхан, 2004, Объект Хандлагатай Геологийн Мэдээллийн Сан Байгуулахын Тухайд, Геологи Сэтгүүл, ШУТИС, Улаанбаатар хот.

3. ArcGIS, Field guide, ESRI, USA.

4. Badji, N., 1991, "An Object-Oriented GIS Based on Linear Quadtrees", *European Conference on GIS*, Munich, Germany, pp.55-59.

5. Burrough, P., 1998, Principles of GIS for Land Resources Assessment, 2nd Ed., *Clarendon Press*, Oxford, UK.

6. David M., and Lauzon, P., "Linear Quadtrees for GISs", 1991, *Proceedings of International Symposium in Spatial Data Handling*, Zurich, Zwizerland, Vol.2,412-430.

7. Fritsh, D., Schilcher, M., and Yang, H., 1988, "Object-Oriented Management of Raster Data in GIS", *International Journal of GIS*, pp.60-69.

8. Jungert, Z., 1991, "A Database Structure For An Object-Oriented Raster-Based GIS", *European Conference on GIS*, Munich, Germany, pp.84-90.